No. 27 Vol.3 Thn. XIV April 2007 ISSN: 854-8471

A STABILIZE ANGLE POSITION OF ARM ROBOT

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ABSTRACT

In modern industrial, there are many object of control system with use for driving special tools and materials transportation is arm robot system. Basically the operation of arm robot system is position control. DC motor is one of the most powerful machines it can be used for tracking the movement of an arm robot. But the problem is how to make a stable condition of the angle position of the arm robot. The answer is Position Control Design. So in this research I did to solve the problem. The control position of the arm robot system consists of DC motor, encoder and other devices. Analyzing the system we applied state feed back for stabilize inverter pendulum. "The Position of Arm Robot" contrel system is realized under digital signal processing controlling DC motor. That applied that system.

THE ARM ROBOT SYSTEM

The Arm Robot Angle Position Control

In our study case how can a feed back system control a arm robot position. The system as like picture in Fig. 2. The arm robot is derived by a DC motor.

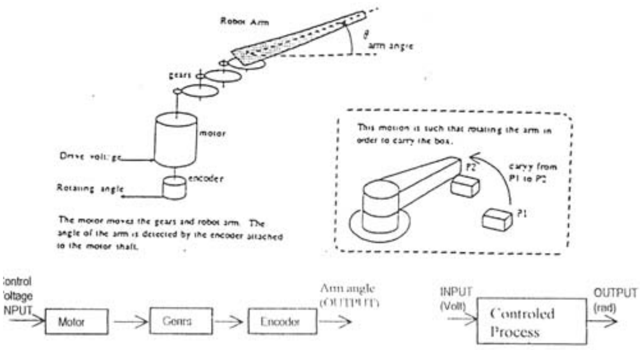


Fig.1 The Arm Robot

Physical Model Of DC Motor

In these control system, the variable being controlled is position. The position is measured by a encoder as sensor.
The Phishical model of the Arm Robot position control

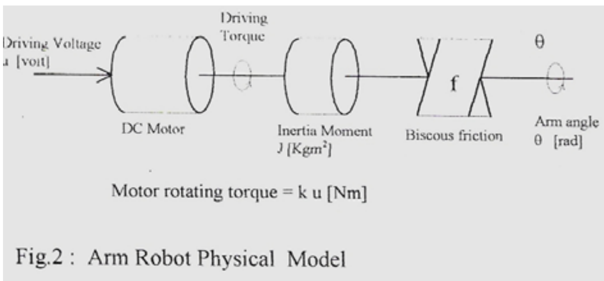


Fig-2 Arm Robot Physical Model

Mathematical Model

From Physical model at Fig-3, It should be described more detail of the model as fig-4 below. And accordance with several theorem basically likes Kirchof, Newton Low and Dynamic equations We can construct mathematical model of the system.

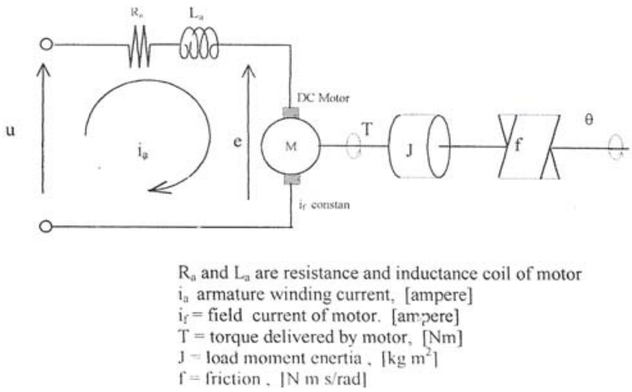


Fig-3 Electrical and Mechanical DC Motor

The torque T delivered by motor is proportional to arrnature current ia and gap the air gap flux ψ. The air gap flux ψ proportional to field current if, it can be wrote as :

$$\psi = kf \, if \qquad (1)$$

kf = constante field current

$$T = kf \, if \; kaia \qquad (2)$$

ka = constante armature current

where ψ = magnetic flux at air gap

By using k= kf if ka it can be

$$T = k \, ia \qquad (3)$$

Because of flux constant so the voltage illduced eb is proportinal to the anguler velocity directly. And it can be wrote that:

$$e_b = k_b \frac{d\theta}{dt} \tag{4}$$

where kb is a back emf constant.

The inpuit voltage u(t) is supplied by amplifier. It can find the differential equation for ia :

$$L_a \frac{di_a}{dt} + R_a i_a + e = u \tag{5}$$

Torque T which be applied to the inertia moment and friction is produced by armatur current. It can be wrote as:

$$J \frac{d^2 t}{dt^2} + f \frac{d\theta}{dt} = T = k i_a \tag{6}$$

In Laplace version we can write the equations 4,5 dan 6 as below:

$$k_b s\Theta(s) = E(s) \tag{7}$$

$$(L_a s + R_a) I_a(s) + E(s) = U(s) \tag{8}$$

$$(Js^2 + fs)\Theta(s) = T(s) = kI_a(s) \tag{9}$$

Accordance with the laplace equation 7,8 dan 9 we make a diagram block of the system. We can the system diagram block at Fig.4 as below:

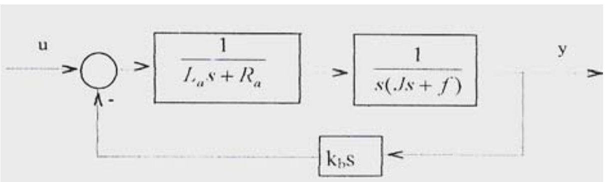


Fig.4: Block Diagram System

The transfer function of the system as:

$$\frac{\Theta(S)}{E(s)} = \frac{k}{s\left[L_a J s^2 + \left(L_a f + R_a J\right)s + R_a f + kk_b\right]} \tag{10}$$

Usually the inductance Ln is small and may he neglected. And as result the transfer function given by equation (10) reduces to:

$$\frac{\Theta(s)}{U(s)} = \frac{k_m}{s(T_m s + 1)} \tag{11}$$

The transfer function is second order and the system's block diagram of "Arm Robot" is :

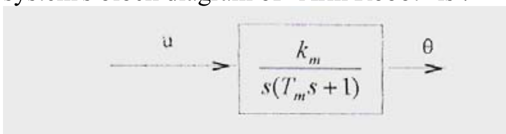


Fig.5: the arm robot open loop transfer function

Experimentally we can find the value of km and Tm

Measure km and T m

In order to measure km and T m the step function (voltage) is supplied to the system. We have already know mathematically an output of the system should be transient function:

$$\theta(t) = k_m \left(1 - e^{-\frac{t}{T_m}}\right) u(t) \tag{12}$$

Where, Tm = arm robot time constant [sec]
km = value of B(t = ∞)) [rad/volt]

In our case for control position of arm robot we used a step function for input system, Based on the input step function it can be obtained the value output parameter in mathematically, let consider Equation 12.

Input step function U(s) = 1 and

$$\theta(t) = \frac{k_m}{T_m}(1 - e^{\frac{-t}{T_m}})$$

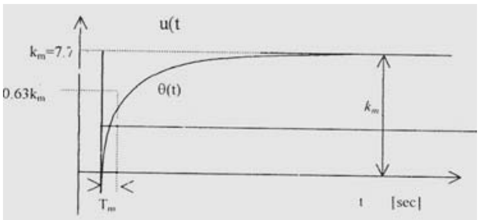
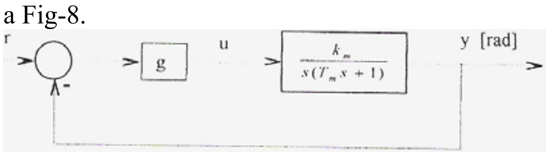


Fig-6 Open loop output response system With a input step function

In experiment it find k_m=7.7 rad/sec and T_m=0.14

Arm Robot Feedback control

The Arm robot position can be controlled by using a feed back control. One of that feed back as a Fig-8.



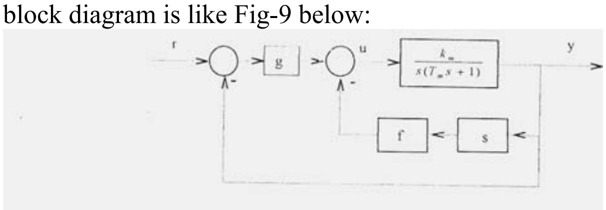
This block diagram is 2 oider and it have 2 poles. We can find it's closed loop transfer function. The transfer function is:

$$\frac{Y(s)}{R(s)} = \frac{\frac{g}{T_m}}{S^2 + \frac{k_m}{T_m}s + \frac{g}{T_m}} \tag{13}$$

A position of poles should be determine a output response of the system. The best response is critically damped. Because the critically damped output response have a shortest time response (taster) and without any overshoot.

So to find the best response (critically damped) we have to chose which poles are suitable for our system. Poles of the c1osed loop transfer function should be consist of complex numbers.

Accordance with equation 12 we can change g parameter constant value. But unfortunately if we change g there only imaginary part of that poles can be changed and there no effect for real part. So to over come this problem it should suggest to change a black diagram with another. The a new system block diagram is like Fig-9 below:



The closed loop transfer ' Fig.8: Feed back control system for arm robot with f canstant.

$$\frac{Y(s)}{R(s)} = \frac{\omega_n^2}{s^2 + \frac{1}{T_m}(1 + k_m f)s + \frac{k_m}{T_m} g} \qquad (14)$$

This equation similar with

$$\frac{Y(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \qquad (15)$$

poles location for the transfer function accordance equation 15 is:

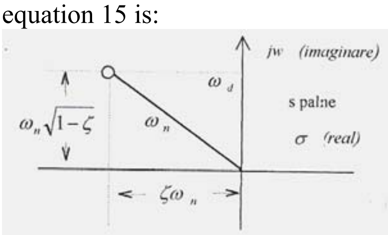


Fig.9: poles location in a s plane

A r(t) input step function will produce an output equation y(t) as below:

$$y(t) = 1 - \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}} \sin(\omega_d t + \tan^{-1}(\frac{\sqrt{1-\zeta^2}}{\zeta} \qquad (16)$$

W_d is imaginary part of poles, and time constant of output response system τ is:

$\tau = \frac{1}{\zeta\omega_n}$. Time constant absolutely detennine a time response of system. If we want to have time response more faster so it need that in mathematically W_n more bigger in our system control design. But it have limitation accordance physical parameter value of the arm robot. And by using the equation 13 we can eval uate or change both of poles part are real and imaginary in order to get best response of the system mathematically.

In order to get a critically jamped output response we should chose the *"damping ratio"* ζ is 0.8.

As we know in experiment we have already find

k_m =7.7 rad/volt and T_m=0.14 sec

By using **g=1.0** We can find the value ofw and feedback parameter f from equation 13 and 14 as below:

$$\omega_n = \sqrt{\frac{k_m}{T_m} g} = \sqrt{\frac{7.7}{0.14}} = 7.3485 \qquad \text{and}$$

$$2\zeta\omega_n = \frac{1}{T_m}(1 + k_m f)$$

And then $$f = \frac{2\zeta\omega_n T_m - 1}{k_m}$$

$$= \frac{(2)(0.8)(7.3485)(0.14) - 1}{7.7}$$

$$f = 0.084$$

Beside of damping ratio and frequency method an we also find a best output response by replacement of poles in try and error method.

Finally we find a curve graphic of output response for:

k_m	= 7.7	[rad/second]
T_m	= 0.14	[second]
G	= 1.0	
F	= 0.084	

As a fig.10 below :

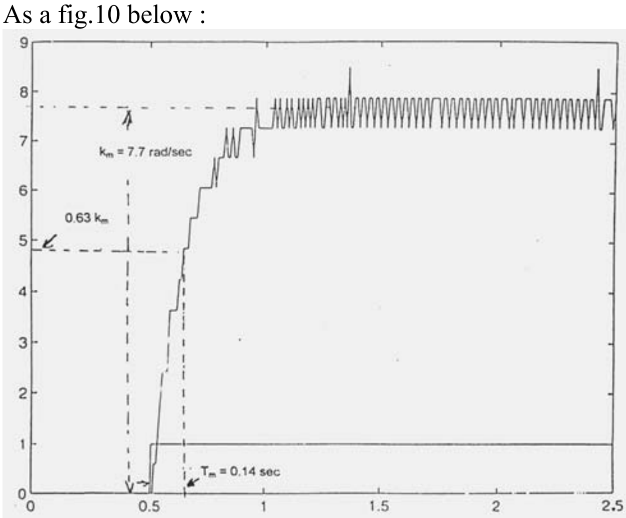


Fig.10:The angle position response system

SUMMARY

- Within non overshot output range condition, we find that the minimal value of time constant response system 0.14 second.
- Couse of gear box histerysis, so the angle Olltput system have a small fibration.
- The limition of DC motor input voltage win determine a speed response of the system